

DESCRIPTION

APPARATUS AND METHODS FOR DELIVERING A CLOSURE DEVICE

5 This application is a continuation-in-part of co-pending application Serial No. 09/610,128<sup>238</sup>, filed July 5, 2000, which is a continuation-in-part of co-pending application Serial No. 09/478,179, filed January 5, 2000, the disclosures of which are  
10 expressly incorporated herein by reference.

FIELD OF THE INVENTION

15 The present invention relates generally to apparatus and methods for closing and/or sealing openings into body lumens, and more particularly to apparatus and methods for delivering a vascular closure element for closing a puncture in a blood vessel formed during a diagnostic or therapeutic procedure.

BACKGROUND

20 Catheterization and interventional procedures, such as angioplasty or stenting, generally are performed by inserting a hollow needle through a patient's skin and muscle tissue into the vascular system. A guide wire may then be passed through the needle lumen into the patient's blood vessel accessed by the  
25 needle. The needle may be removed, and an introducer sheath may

be advanced over the guide wire into the vessel, e.g., in conjunction with or subsequent to a dilator. A catheter or other device may then be advanced through a lumen of the introducer sheath and over the guide wire into a position for performing a medical procedure. Thus, the introducer sheath may facilitate introduction of various devices into the vessel, while minimizing trauma to the vessel wall and/or minimizing blood loss during a procedure.

Upon completion of the procedure, the devices and introducer sheath may be removed, leaving a puncture site in the vessel wall. External pressure may be applied to the puncture site until clotting and wound sealing occur. This procedure, however, may be time consuming and expensive, requiring as much as an hour of a physician's or nurse's time. It is also uncomfortable for the patient, and requires that the patient remain immobilized in the operating room, catheter lab, or holding area. In addition, a risk of hematoma exists from bleeding before hemostasis occurs.

Various apparatus have been suggested for percutaneously sealing a vascular puncture by occluding the puncture site. For example, U.S. Patent Nos. 5,192,302 and 5,222,974, issued to Kensey et al., describe the use of a biodegradable plug that may be delivered through an introducer sheath into a puncture site.

When deployed, the plug may seal the vessel and provide hemostasis. Such devices, however, may be difficult to position properly with respect to the vessel, which may be particularly significant since it is generally undesirable to expose the plug material, e.g., collagen, within the bloodstream, where it may float downstream and risk causing an embolism.

Another technique has been suggested that involves percutaneously suturing the puncture site, such as that disclosed in U.S. Patent No. 5,304,184, issued to Hathaway et al.

Percutaneous suturing devices, however, may require significant skill by the user, and may be mechanically complex and expensive to manufacture.

To facilitate positioning devices that are percutaneously inserted into a blood vessel, "bleed back" indicators have been suggested. For example, U.S. Patent No. 4,317,445, issued to Robinson, discloses a flashback chamber on a first end of a cannula that communicates with a port on a second end. The second end is percutaneously introduced into a patient until the port enters the vessel, whereupon blood, under normal blood pressure, may advance along the cannula and enter the flashback chamber, thereby providing a visual indication that the vessel has been entered. This reference, however, does not discuss

vascular wound closure, but is merely directed to an introducer device. In contrast, U.S. Patent No. 5,676,974, issued to Kensey et al., discloses a bleed back lumen intended to facilitate positioning of a biodegradable plug within a puncture site. This  
5 device, however, requires that an anchor of the plug be positioned within the vessel, and therefore, may increase the risk of over-advancement of the plug itself into the vessel.

Alternatively, U.S. Patent No. 5,674,231, issued to Green et al., discloses a deployable loop that may be advanced through a  
10 sheath into a vessel. The loop is intended to resiliently expand to engage the inner wall of the vessel, thereby facilitating holding the sheath in a desired location with respect to the vessel. The loop may also provide a support for facilitating the deployment and deflection of a surgical clip against the vessel  
15 wall. Such a device, however, may risk engagement between the loop and the surgical clip, thereby preventing the loop from being withdrawn from the vessel.

Accordingly, apparatus and methods for delivering a device for closing a vascular puncture site would be considered useful.

SUMMARY OF THE INVENTION

The present invention is directed to apparatus and methods for closing and/or sealing openings into body lumens, and more particularly to apparatus and methods for delivering a vascular closure element for closing a puncture in a blood vessel formed during a diagnostic or therapeutic procedure.

In accordance with one aspect of the present invention, an apparatus is provided for delivering a closure element into engagement with tissue adjacent an opening into a body lumen.

10 The apparatus includes a sheath including a lumen extending between its proximal and distal ends, and a locator member disposed within the sheath, the locator member having a distal portion extending distally beyond the distal end of the sheath. One or more positioning elements are provided on the distal portion of the locator member, the positioning elements being selectively expandable between a substantially axial collapsed configuration and a substantially transverse expanded configuration. Preferably, the positioning elements are a plurality, e.g. two or more, equally spaced, substantially flexible splines or wings configured for expanding substantially transversely to a longitudinal axis of the sheath. Each spline may have a first fixed end and a second movable end, the second

end being axially movable towards the first end to cause an intermediate region of the spline to expand radially outward, thereby defining the radially expanded configuration.

Alternatively, the splines may include a plurality of

5 substantially rigid or semi-rigid elements that are hinged such that the splines may be expanded to the expanded configuration.

An actuator may be coupled to the locator member, the actuator configured for controllably expanding the positioning elements from the collapsed configuration to the expanded  
10 configuration. The actuator may include a control such that the positioning elements may be selectively expanded to one of a plurality of expanded sizes, e.g., to accommodate insertion into vessels of various sizes.

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15 A housing may be axially slidably disposed on an exterior of the sheath, the housing configured for releasably holding a closure element, the housing being actuable for advancing the closure element distally to deploy the closure element. In a preferred embodiment, the locator actuator may be configured for automatically collapsing the positioning elements to the  
20 collapsed configuration upon advancement of the housing to prevent engagement between the closure element and the positioning elements. The housing may be substantially

permanently but slidably disposed on the sheath. Alternatively, the housing may be provided separate from the sheath, e.g., with the closure element pre-loaded therein. The housing may be directed over the sheath, e.g., over the proximal end of the sheath, at any time before delivery of the closure element.

In accordance with another aspect of the present invention, a method is provided for delivering a closure element into a passage communicating with an opening in a wall of a body lumen. An introducer sheath is positioned through a patient's skin towards the body lumen via the passage, the sheath including a lumen extending between its proximal and distal ends. One or more instruments may be introduced through the lumen of the sheath into the body lumen. A diagnostic or therapeutic procedure may be performed using the one or more instruments at a location accessed via the body lumen.

In a preferred embodiment, the body lumen is a blood vessel, such as a peripheral vessel, e.g., the femoral or carotid artery. The procedure may be any of a variety of endovascular procedures, such as angioplasty, atherectomy, stent delivery, delivery of a therapeutic agent, and tissue ablation.

Upon completion of the procedure, the devices may be removed from the sheath. A locator may be inserted along or through the

sheath until a distal portion of the locator extends beyond the distal end of the sheath and into the body lumen. One or more positioning elements on the distal portion of the locator may be expanded from a collapsed configuration to an expanded

5 configuration.

The sheath and locator may then be manipulated with respect to the body lumen until the positioning elements in their expanded configuration contact the wall of the body lumen, thereby providing a tactile indication of a location of the distal end of the sheath. A closure element may then be delivered via the sheath into the passage. The sheath and locator may be withdrawn from the body lumen and opening, leaving the closure element to substantially close the opening.

In a preferred embodiment, the closure device is delivered via a housing slidably attached to the sheath. The housing may be advanced distally, e.g., along an exterior of the sheath, the housing having the closure device detachably held thereto. In a preferred method, the positioning elements may automatically return to the collapsed configuration when the housing is advanced to its distal position, thereby avoiding engagement between the closure element and the positioning elements.

Alternatively, the positioning elements may automatically



collapse when an ejector is activated to deploy the closure element from the housing, e.g., after the housing has been advanced to its distal position.

Other objects and features of the present invention will become apparent from consideration of the following description taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of an apparatus for delivering a closure element, including an introducer sheath, a locator, and an actuator assembly, in accordance with the present invention.

FIG. 2 is a side view of the apparatus of FIG. 1, with the locator disposed within the sheath, and a housing on the sheath advanced to a delivery position.

FIGS. 3A and 3B are perspective views of the distal end of the apparatus of FIGS. 1 and 2, showing positioning elements on the locator in collapsed and expanded configurations, respectively.

FIGS. 4A-4F are cross-sectional views of a blood vessel, showing a method for delivering a closure device into a passage communicating with the vessel.

FIG. 5 is a cross-sectional view of the blood vessel of FIG. 4D, showing the positioning elements engaging a wall of the vessel.

FIG. 6 is a perspective view of an alternate embodiment of a distal portion of the locator with the positioning elements disposed in their expanded configuration.

FIGS. 7A and 7B are side views of another embodiment of a distal portion of a locator with positioning elements disposed in collapsed and expanded configurations, respectively.

FIGS. 8A and 8B are side views of the locator of FIGS. 7A and 7B, including a control on the locator for adjusting the expansion of the positioning elements.

FIG. 9 is a cross-section view of a distal portion of an alternative embodiment of an apparatus for delivering a closure element, in accordance with the present invention.

FIG. 10 is a cross-sectional view of a distal portion of yet another alternative embodiment of an apparatus for delivering a closure element, in accordance with the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to the drawings, FIGS. 1-2 show a first preferred embodiment of an apparatus 10 for providing access into

a blood vessel or other body lumen from an incision, puncture, or other passage (not shown in FIGS. 1 and 2), and/or for delivering a closure element, such as clip 26 (shown in phantom), for closing the passage. Generally, the apparatus 10 includes an  
5 introducer sheath 12, a housing 24 slidably disposed on the sheath 12, a locator member 14 insertable into the sheath 12, and an housing actuator assembly 30.

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10 The sheath 12 includes a substantially flexible or semi-rigid tubular body 15 including a lumen 16 extending between its proximal and distal ends 18, 20. The distal end 20 has a size and shape to facilitate insertion into a blood vessel, e.g., having a tapered tip 22 for facilitating substantially atraumatic introduction through the passage and at least partially into the vessel. The lumen 16 has a size for accommodating insertion of  
15 one or more devices therethrough, such as a catheter, guidewire, and the like (not shown). The sheath 12 also preferably includes a seal (not shown), such as a hemostatic valve, within the lumen 16 at or near the proximal end 18 that provides a fluid-tight seal, yet accommodates insertion of one or more devices, such as  
20 the locator 14, into the lumen 16 without fluid passing proximally from the sheath 12.

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000

Optionally, the sheath 12 may include a side port 19 that communicates with the lumen 16, for example, to allow the infusion of fluids into the lumen 16, through the sheath 12. Alternatively, or in addition, the side port 19 may be used to provide a "bleed back" indicator, such as that disclosed in co-pending application Serial No. \_\_/\_\_\_\_\_, filed October 6, 2000, entitled "Apparatus and Methods for Positioning a Vascular Sheath," which is assigned to the assignee of the present invention. The disclosure of this application and any references cited therein are expressly incorporated herein.

A housing 24 is slidably disposed on an exterior of the sheath 12, the housing 24 configured for releasably holding the closure element 26. The housing 24 may include an ejector or other mechanism (not shown) for deploying the closure element 26 from the housing 24. In a preferred embodiment, the closure element 26 is an annular-shaped clip, including one or more barbs 28 for engaging the tissue around the puncture adjacent to the wall of the vessel. Preferably, the clip 26 is configured for drawing the tissue around the puncture at the wall of the vessel substantially closed and/or for enhancing hemostasis within the puncture. Exemplary embodiments of a housing and closure element for use with an apparatus in accordance with the present

invention are disclosed in co-pending application Serial Nos. 09/478,179, 09/546,998, and 09/610,238, the disclosures of which are expressly incorporated herein by reference.

5 The housing 24 is actuable from the proximal end 18 of the sheath 12 (FIG. 1), for example, by housing actuator assembly 30, for advancing the closure element 26 distally during deployment. The housing 24 may be substantially permanently but slidably disposed on the sheath 12. In this embodiment, the housing actuator assembly 30 may be substantially permanently attached to 10 the proximal end 18 of the sheath 12. The housing 24 may be coupled to the housing actuator assembly 30 such that the housing 24 may be directed axially along the exterior of the sheath.

15 Alternatively, the housing 24 may be provided separate from the sheath 12 (not shown), e.g., with the closure element 26 pre-loaded therein. In this embodiment, the housing actuator assembly 30 may also be provided separate from the sheath 12, as shown, either coupled to or separate from the housing 24. Any time before delivering the closure element 26, the housing 24 may be directed over the sheath 12, e.g., by inserting the proximal 20 end 18 of the sheath 12. The housing actuator assembly 30 may be attached to the proximal end 18 of the sheath 12, e.g., by cooperating connectors (not shown). The housing 24 may be

coupled to the housing actuator assembly 30, if not already attached, thereby preparing the housing 24 for use.

In a preferred embodiment shown in FIGS. 1 and 2, the housing actuator assembly 30 includes first and second actuator members 46, 48 that are generally movable with respect to one another. The first actuator member 46 may be connected to the proximal end 18 of the sheath 12, for example, by rods (not shown) such that the first member 46 is substantially fixed with respect to the sheath 12. A rod, cable, or other control wire 44 is coupled to and extends generally proximally from the housing 24. The control wire 44 may extend along an outer surface of the sheath 12, as shown, or alternatively may extend through a lumen (not shown) in the sheath 12 beyond the proximal end 18.

A loose end 50 of the control wire 46 may be coupled to the second actuator member 48. For example, the housing actuator assembly 30 may be advanced over the control wire 46 such that the loose end 50 passes through aperture 52 in the first member 46 and is received in a mating pocket 54 in the second member 48, as best seen in FIG. 2. The loose end 50 may be frictionally engaged within the pocket 54 or, alternatively, the loose end 50 and pocket 54 may include cooperating detents (not shown) for securing the control wire 44 to the second actuator member 48.

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The second actuator member 48 may be movable with respect to the first actuator member 46 by one or more rods or rails (not shown) extending therebetween. Thus, the second actuator member 48 may be movable from a first or proximal position (not shown),  
5 located a first distance from the first actuator member 46, distally to a second or distal position (shown in FIG. 2), located a second closer distance from the first actuator member 46. When the housing actuator assembly 30 is attached to the sheath 12 with the control wire 44 coupled to the second actuator  
10 member 48, the housing 24 may be directed from a proximal position (e.g., shown in FIG. 1) to a distal or delivery position (e.g., shown in FIG. 2) when the second actuator member 48 is moved from its proximal position to its distal position.

15 In a preferred embodiment, the second actuator member 48 is biased to its distal position, for example, by spring 56 or other biasing element. The second actuator member 48 may be locked in its proximal position, for example, by a locking mechanism (not shown), thereby retaining the housing 24 in its proximal position. When it is desired to advance the housing 24, a  
20 button, switch, or other activation member (not shown) may be deployed to release the locking mechanism, thereby automatically directing the second actuator member 48 towards the first

actuator member 46, and thereby advancing the housing 24 to its distal position, as described further below. The closure element 26 may be automatically ejected from the housing 24 once it reaches the distal position or the closure element 26 may be subsequently ejected by a separate action. It will be appreciated by those skilled in the art that other housing actuator configurations may be provided for advancing the housing 24 with respect to the sheath 12, e.g., to deliver the closure element 26.

The housing actuator assembly 30 may also include an adjustment mechanism, such as threaded bolt or knob 58. For example, the knob 58 may be provided on the first actuator member 46 such that, as the knob 58 is rotated, the first actuator member 46 may be moved axially with respect to the sheath 12. Because the first actuator member 46 may be adjusted distally or proximally with respect to the sheath 12, the distal position of the second actuator member 48 consequently may be adjusted. This, in turn, may facilitate adjusting the distal position of the housing 24, e.g., to compensate for the thickness of a particular wall of a blood vessel when a closure element 26 is delivered to close a puncture in the wall.



Turning to FIGS. 1, 2, 3A, and 3B, the locator member 14 includes a flexible or semi-rigid tubular body or other elongate rail 32 having a proximal end 34 and a distal end 36. An actuator rod or other elongate member 38 is slidably disposed with respect to the rail 32, e.g., within a lumen 33 of tubular body 32. Preferably, the locator member 14 includes an annular ridge 40 or other detent on or near its proximal end 40 that may engage a complementary-shaped pocket 42 or other cooperating detent on the sheath 12. Thus, the locator member 14 may be substantially secured axially with respect to the sheath 12.

As best seen in FIGS. 3A and 3B, a distal portion 60 of the locator member 14 includes a substantially rounded, soft, and/or flexible distal tip 62, possibly including a pigtail (not shown) that may facilitate atraumatic advancement of the distal portion 60 into a blood vessel or other body lumen. The locator member 14 preferably has a length relative to the sheath 12 such that the distal portion 60 extends beyond the distal end 20 of the sheath 12 when the locator member 14 is fully received therein, as shown in FIG. 2.

One or more, and preferably a plurality of, positioning elements 64 are provided on the distal portion 60 that may be selectively expandable between a substantially axial collapsed

configuration (shown in FIG. 3A) and a substantially transverse expanded configuration (shown in FIG. 3B). Preferably, the positioning elements 64 are substantially flexible splines configured for expanding substantially transversely with respect to a longitudinal axis 13 of the apparatus 10. In one embodiment, shown in FIGS. 1 and 2, the locator member 14 includes a pair of splines 64 disposed generally opposite one another about the distal portion 60. Alternatively, as shown in FIG. 6, the locator member 14 may include four splines 64' that are substantially equally spaced about the distal portion 60. The locator member 14 may include more or fewer splines without deviating from the scope of the present invention.

Optionally, the splines 64 may include radiopaque markers (not shown) or may be at least partially formed from radiopaque material to facilitate observation of the splines 64 using fluoroscopy or other imaging systems. In addition, the housing 24 may include a radiopaque marker, e.g., at its distal end (not shown) and/or the closure element 26 may include a radiopaque marker or may be made from radiopaque material. This may facilitate monitoring the relative location of the closure element 26 to the splines 64, as described further below.

Returning to FIGS. 3A and 3B, each spline 64 preferably has a first fixed (e.g., proximal) end 64a and a second movable (e.g., distal) end 64b. The second end 64b may be axially movable towards the first end 64a to cause an intermediate region 5 64c of the spline 64 to expand transversely outward, thereby defining the substantially transverse expanded configuration. In a preferred embodiment, actuator rod 38 extends through the distal portion 60 and is coupled to the second end 64b of the splines 64 and/or to distal tip 62 of the locator member 14. The 10 rod 38 may be moved axially, e.g., proximally, with respect to the rail 32 to selectively expand the splines 64 between their collapsed configuration and their expanded configuration.

A locator actuator 70 may be coupled to the locator member 14, the locator actuator 70 configured for selectively expanding 15 the splines 64 from their collapsed configuration to their expanded configuration. For example, the locator actuator 70 may include a switch 72 that may be depressed or rotated to retract or move the rod 38 proximally, thereby expanding or deploying the splines 64. The locator actuator 70 preferably includes a lock 20 (not shown) for securing the rod 38 in a proximal position and thereby locking the splines 64 in their expanded configuration. The lock may be released, for example, by depressing the switch

72. The locator actuator 70 may include a spring 74 or other  
biasing mechanism for biasing the rod 38 distally, e.g., to  
return the splines 64 to their collapsed configuration when the  
lock is released. For example, as described further below, the  
5 lock may be released upon activation of the housing actuator  
assembly 30, e.g., when the second actuator member 48 moves  
towards its distal position.

Turning to FIGS. 4A-4F, the apparatus 10 may be used to  
provide access into a blood vessel or other body lumen 90.  
10 Preferably, the apparatus 10 may be used to deliver a closure  
device, such as clip 26, to close and/or seal an incision,  
puncture, or other passage 92 that extends from a patient's skin  
94 through intervening tissue 96, and a wall 98 of the vessel 90.

As shown in FIG. 4A, the sheath 12, without the locator  
15 member 14 therein, may be inserted or otherwise positioned within  
the blood vessel 90, i.e., through the passage 92. The sheath 12  
is preferably provided with the housing 24 in its proximal  
position, without the housing actuator assembly (not shown)  
attached. Alternatively, the housing actuator assembly may be  
20 provided attached to the sheath 12 as long as the lumen 16 may be  
accessed. In a further alternative, the sheath 12 may be  
provided without the housing 24 thereon. The sheath 12 may be

advanced over a guide wire or other rail (not shown) previously positioned through the passage 92 into the blood vessel 90 using a conventional procedure. Preferably, the blood vessel 90 is a peripheral vessel, such as a femoral or carotid artery, although  
5 other body lumens may be accessed using the sheath 12, as will be appreciated by those skilled in the art.

The passage 92, and consequently the sheath 12, may be oriented at a substantially acute angle "alpha" with respect to the vessel 90, thereby facilitating introduction of devices  
10 through the lumen 16 of the sheath 12 into the vessel 90 with minimal risk of damage to the vessel 90. One or more devices, such as a guide wire, a catheter, and the like (not shown), may be inserted through the sheath 12 and advanced to a desired location within the patient's body. For example, the devices may  
15 be used to perform a therapeutic or diagnostic procedure, such as angioplasty, atherectomy, stent implantation, and the like, within the patient's vasculature.

After the procedure is complete, the device(s) may be removed from the sheath 12, and the locator member 14 may be  
20 inserted through the hemostatic valve (not shown) into the lumen 16. If the housing 24 is not already provided on the sheath 12, the housing 24 and/or the housing actuator assembly (not shown)

may be advanced over or otherwise attached to the proximal end of the sheath 12, preferably before the locator member 14 is inserted into the sheath 12.

As shown in FIG. 4B, when the locator member 14 is fully inserted within the sheath 12, the distal portion 60 extends beyond the distal end 20 of the sheath 12. In an alternative embodiment, the locator member 14 may be attached to an exterior surface (not shown) of the sheath 12, for example, along a track, e.g., cooperating slots, grooves, and the like (not shown) in the sheath 12 and locator member 14. The distal tip 62 preferably is substantially soft and/or flexible such that the distal portion 60 substantially atraumatically enters the vessel 90. In this fully inserted position, cooperating detents (not shown) may be engaged to substantially secure the locator member 14 axially with respect to the sheath 12. The housing actuator assembly (not shown) may be attached to the sheath 12, e.g., by attaching a control wire (not shown) from the housing 24 to the actuator assembly, as described above.

Alternatively, the sheath 12 may include a side port (not shown) at or near its distal end 20 and a bleed back lumen (also not shown) that extends from the side port to the proximal end of the sheath 12. Before or after insertion of the locator member

14, the sheath 12 may be manipulated until "bleed back" (i.e., blood entering the side port and passing proximally through the lumen due to exposure of the side port to blood pressure within the vessel) indicates a desired position for the distal end 20 of the sheath 12. For example, the sheath 12 may be partially withdrawn from the vessel 90 before the locator member 14 is inserted into the sheath 12 to minimize contact between the vessel wall 98 and the distal portion 60 of the locator member 14 during insertion of the locator member 14 into the sheath 12.

As shown in FIG. 4C, the splines 64 may then be directed to their expanded configuration, for example, by activating a switch on the proximal end (not shown) of the locator member 14. The sheath 12 and locator member 14 may then be moved in conjunction with one another, and preferably are together partially withdrawn from the vessel 90, until the splines 64 contact the wall 98 of the vessel 90, as shown in FIG. 4D. Thus, the splines 64 may provide a tactile indication of the position of the sheath 12 with respect to the wall 98 of the vessel 90. In addition, the splines 64 may assist in "presenting" the wall 98 of the vessel 90, e.g., for receiving a closure element, such as clip 26.

Turning to FIG. 4E, with the sheath 12 properly positioned, the housing 24 may then be actuated, for example, to advance the

housing 24 distally into the passage 92 to deliver the clip 26. Preferably, movement of the housing 24 with respect to the distal end 20 of the sheath 12 is limited, e.g., by the housing actuator assembly (not shown), as described above. Preferably, the

5 housing 24 may only be advanced a fixed distance such that the clip 26 substantially engages the wall 98 of the blood vessel, e.g., until the barbs 28 penetrate but do not pass completely through the wall 98. Thus, with the splines 64 fixed with respect to the distal end 20 of the sheath 12 and the distal position of the housing 24 fixed, the clip 26 may be advanced a  
10 predetermined distance into the passage 92 that is ascertainable and predictable. This predetermined distance may facilitate proper deployment of the clip 26 with respect to the wall 98 of the vessel 90, e.g., to prevent advancement of the clip 26 too  
15 far, i.e., into the vessel 90.

Alternatively, or in addition, the splines 64 include radiopaque markers, such that fluoroscopy and the like may be used to monitor and position the distal portion 60 of the locator member 14. The housing 24 and/or closure element 26 may also  
20 include radiopaque markers such that a relative position of the closure element 26 with respect to the splines 64, and



consequently to the wall 98 of the vessel 90, may be ascertained before the closure element 26 is deployed from the housing 24.

In a preferred method, the splines 64 automatically return to their collapsed configuration when the closure element 26 is deployed from the housing 24 or when the housing 24 reaches its distal position, as shown in FIG. 4F. For example, the housing actuator assembly (not shown) may contact the locator actuator (also not shown) when the housing actuator assembly is used to advance the housing 24 to its distal position, thereby releasing the locator actuator. This enhancement may avoid any risk of contact between the clip 26 and the splines 64, e.g., which otherwise may risk driving the barbs 28 of the clip 26 through the wall 98 of the vessel 90 and into the splines 64. Alternatively, or in addition, the distal portion 60 of the locator member 14 may be automatically retracted, e.g., into the sheath 12, when the closure element 26 is deployed or the housing 24 is advanced.

Once the clip 26 is successfully deployed within the passage 92, i.e., into the wall 98 of the vessel 90, the apparatus 10 may be withdrawn from the passage 92. If the splines 64 of the locator member 14 are not automatically collapsed during advancement of the housing 24, the splines 64 may first be

affirmatively collapsed, e.g., by depressing the locator actuator (not shown). The entire apparatus 10 may then be removed in one step, or alternatively, the locator member 14 may first be withdrawn from the sheath 12 before withdrawing the sheath 12, thereby leaving the clip 26 in place to close and/or seal the passage 92.

Turning to FIGS. 7A and 7B, another embodiment of a distal portion 160 of a locator member 114 is shown that may be used to position a sheath (not shown) before delivering a closure element (also not shown), similar to the embodiment described above. The locator member 114 includes a flexible or semi-rigid tubular body 132 having a proximal end (not shown) and a distal end 136. An actuator wire or rod 138 is slidably disposed with respect to the body 132, e.g., within a lumen 133 of body 132. The locator member 114 may include a detent (not shown) on or near its proximal end for securing the locator member 114 to a sheath (not shown).

The locator member 114 includes a distal portion 160 that terminates in a substantially rounded, soft, and/or flexible distal tip 162, possibly including a pigtail (not shown) that may facilitate atraumatic advancement of the distal portion 160 into a blood vessel or other body lumen. The locator member 114

preferably has a length relative to the sheath such that the distal portion 160 extends beyond a distal end of the sheath when the locator member 114 is fully received in the sheath, similar to the embodiment described above.

5 ~~5/23/23~~ A plurality of splines 164 are provided on the distal portion 160 that may be selectively expandable between a substantially collapsed configuration (shown in FIG. 7A) and a substantially transverse expanded configuration (shown in FIG. 7B). Preferably, the splines 164 are substantially rigid or  
10 semi-rigid elements that include hinged regions 166, 168 that facilitate expansion substantially transversely with respect to a longitudinal axis 113 of the locator member 114. In one  
15 embodiment, each spline 164 is a single piece that includes a plurality of living hinges 166, 168. Alternatively, each spline 164 may include multiple segments that are connected by pins or other hinges (not shown). In a preferred embodiment, the distal  
20 portion 160 includes four equally spaced splines 164, although the locator member 14 may include more or fewer splines without deviating from the scope of the present invention. Optionally, the splines 164 may include radiopaque markers (not shown), similar to the embodiment described above.

Each spline 164 preferably has a first fixed end 164a and a second movable end 164b. The second end 164b may be axially movable towards the first end 164a to cause an intermediate region 164c of the spline 64 to expand transversely outward, thereby defining the substantially transverse expanded configuration. In a preferred embodiment, the actuator rod 138 extends through the distal portion 160 and is coupled to the second end 164b of the splines 164 and/or to distal tip 162 of the locator member 114. The rod 138 may be moved axially with respect to the body 132 to selectively expand the splines 164 between the collapsed and expanded configurations.

Turning to FIG. 8A, a locator actuator 170 may be coupled to the control rod 138 and a proximal end 134 of the locator member 114. The locator actuator 170 is configured for directing the control rod 138 axially to selectively expand the splines 164, similar to the embodiment described above.

In addition, the locator actuator 170 may allow the splines 164 to be expanded to one of a plurality of expanded configurations. For example, the locator actuator 170 may include an internal member (not shown), coupled to the control rod 138, that is slidable within an actuator body 176. A button 172 extending from the internal member is slidable in an axial

slot 174 in the actuator body 176 for controlling movement of the control rod 138. The button 172 may be moved, thereby moving the control rod 138 and consequently moving the splines 164. For example, as shown in FIG. 8A, the button 172 may be moved to a position (for example, indicated as "4") thereby expanding the splines 164 to an expanded diameter 165a. If desired, the button 172 may be moved to other available positions to reduce the expanded diameter, for example to the diameter 165b shown in FIG. 8B. This control of the expanded diameter of the splines 164 may be useful to allow the splines 164 to be deployed within body lumens of different sizes. Thus, the splines 164 may be expanded to a desired size corresponding to the size of the vessel into which the locator 114 is introduced, thereby minimizing the risk of damage to the vessel due to over expansion of the splines 164.

In an alternative embodiment, shown in FIG. 8B, the locator actuator 170' may include a rotatable dial that controls expansion of the splines 164, similar to the linear actuator 170 shown in FIG. 8A. In addition, the locator actuator 170, 170' may include demarcations indicating a size (not shown), e.g., a diameter of the expanded splines and/or the size of the body lumen corresponding to the size of the lumen into which the locator 114 is to be introduced.

Sub 24  
In a further alternative, shown in FIG. 9, a locator member 214 may be provided that includes splines 264 that may be selectively expanded to different angles. A locator actuator (not shown) may allow controlled expansion of the splines 264a, 264b to desired angles with respect to the longitudinal axis 213 of the locator member. For example, a cable or other control wire (not shown) may be extend from the locator actuator to each of the splines 264a, 264b, e.g., through a lumen (not shown) in the locator body 232. Each cable may be directed axially to selectively expand or collapse the spline 264a, 264b connected to the respective cable.

Sub 24  
For example, a spline 264b on the posterior side of the locator member 214 (away from the surface of the patient's skin) may be expanded towards the proximal end of the locator member 214 at an acute angle "alpha," i.e., corresponding substantially to the angle of the passage through the patient's skin to the vessel 90, e.g., about thirty or forty five degrees. In contrast, the spline 264a on the anterior side of the locator member 214 (i.e. towards the surface of the patient's skin) may be expanded away from the proximal end of the locator member 214 at an oblique angle of one hundred eighty degrees less "alpha." Thus, the splines 264 may be expanded to predetermined angles

that facilitate better contact with the wall of the vessel, e.g., to better "present" the vessel wall during deployment of a closure element.

In yet another alternative embodiment, shown in FIG. 10, a locator member 314, such as those described above, may include a tubular sleeve 315 within which a body 332, including splines 364, may be axially directed. For example, a proximal end (not shown) of the sleeve 315 may be fixed to a proximal end (also not shown) of the body 332, e.g., to a locator actuator (not shown), such as those described above. At least a distal portion 317 of the sleeve 315 is formed from a substantially rigid, smooth walled tube, such as a hypotube, while the remainder of the sleeve 315 may be a portion of the same tube or may be formed from a substantially flexible or semi-rigid tubular member (not shown).

When the locator member 314 is fully inserted into an introducer sheath 12, such as those described above, the distal portion 317 of the sleeve 315 extends beyond a distal end 20 of the sheath 12. The splines 364 may then be selectively deployed from within the sleeve 315, expanded to a substantially transverse expanded configuration, collapsed, and retracted back into the sleeve 315.

For example, the sheath 20 may be positioned through a puncture 92 into a vessel 90, e.g., to perform a procedure within a patient's vasculature, as described above. The locator member 314 may then be inserted into the sheath 12 until the distal portion 317 extends beyond the distal end 20 of the sheath 12. The splines 364 may then be expanded, and the sheath 12 and locator member 314 manipulated to a desired position, e.g., such that the splines 364 contact the wall 98 of the vessel 90, thereby providing a tactile indication of the position of the sheath 12.

A closure element, such as clip 26 may then be deployed, e.g., from a housing (not shown) slidably mounted on the sheath 12. Barbs or tines 28 on the clip 26 penetrate into the wall 98 of the vessel 90, e.g., to close the opening in the wall 98 of the vessel 90, as described above. If the barbs 28 penetrate completely through the wall 98 of the vessel 90, the sleeve 315 protects the splines 364 and/or the body 33 of the locator member 314. The barbs 28 may engage but not penetrate or otherwise catch on the distal portion 317 of the sleeve 315, because of its substantially rigid and/or smooth construction. Thus, the barbs 28 may not penetrate or otherwise catch on the splines 364 when the clip 26 is deployed. The splines 364 may be collapsed and



retracted into the sleeve 315, either manually or automatically,  
similar to the embodiments described above. When the sheath 12  
is withdrawn from the puncture 92, the barbs 28 may slide along  
the distal portion 317 of the sleeve 315 until the distal portion  
5 317 is withdrawn from within the clip 26, whereupon the barbs 28  
may move inwards to close and/or seal the opening in the wall  
98 of the vessel 90.

In alternative embodiments, the apparatus and methods of the  
present invention may be used to locate an introducer sheath  
10 within a blood vessel and/or to deliver closure elements other  
than a clip. For example, the apparatus may be used to deliver a  
collagen plug and the like into the passage, or a sealing  
material (either alone, or in conjunction with a clip).

While the invention is susceptible to various modifications,  
15 and alternative forms, specific examples thereof have been shown  
in the drawings and are herein described in detail. It should be  
understood, however, that the invention is not to be limited to  
the particular forms or methods disclosed, but to the contrary,  
the invention is to cover all modifications, equivalents and  
20 alternatives falling within the spirit and scope of the appended  
claims.